Control Systems

G V V Sharma*

Contents

***Abstract*—The objective of this manual is to introduce control system design at an elementary level.**

Download python codes using

```
svn co https://github.com/gadepall/school/trunk/
    control/ketan/codes
```

1 Polar Plot

1.1 Introduction

2 Bode Plot

2.1 Gain and Phase Margin

2.1. For a Transfer function G(s) in unity negative feedback ,whose error $K_v = 2$. Determine K

$$G(s) = \frac{K}{s(s+2)(s+4)(s+6)} \tag{2.1.1}$$

Solution: For unity feedback we have Velocity error constant (K_v)

$$K_v = \lim_{s\to 0} sG(s) \tag{2.1.2}$$

$$\lim_{s\to 0}\left(\frac{K}{(s+2)(s+4)(s+6)}\right) = 2 \tag{2.1.3}$$

$$\implies K = 96 \tag{2.1.4}$$

It's Phase Margin = 19°
and Gain Crossover Frequency = 1.49 rad/s

*The author is with the Department of Electrical Engineering, Indian Institute of Technology, Hyderabad 502285 India e-mail: gadepall@iith.ac.in.

2.2. Design a lead Compensator to yield a Phase margin of 30°

Solution: So ,we need a phase lead of 11 at the gain crossover frequency, Using a lead Compensator C(s).

$$C(s) = \frac{(s+a_1)}{(s+a_2)} \tag{2.2.1}$$

Now choose a_1 and a_2 ($a_1 < a_2$) such that, phase lead of Compensator is 11, and has negligible gain.

$$a_1 = 1.28 \tag{2.2.2}$$

$$a_2 = 1.6 \tag{2.2.3}$$

Refer Fig2.3 for plot C(s).

```
codes/ee18btech11049/lead.py
```

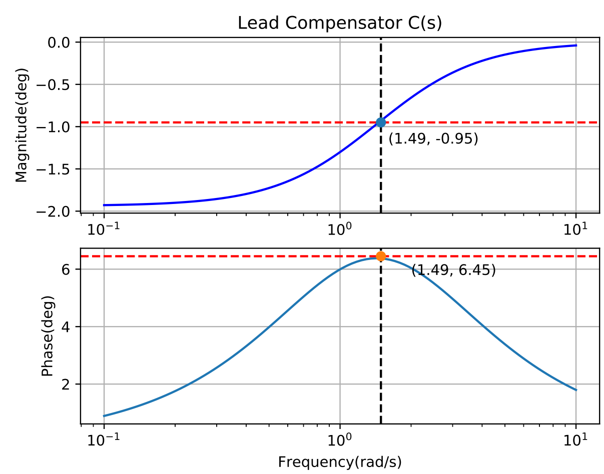

Fig. 2.2

2.3. Plot overall graph after adding lead compensator. Refer Fig2.2 for plot C(s)G(s).

```
codes/ee18btech11049/full.py
```

NOTE : Overall Gain is definitely changed by Lead compensator, which increases gain crossover frequency. This points should be noted while designing a controller, and param-

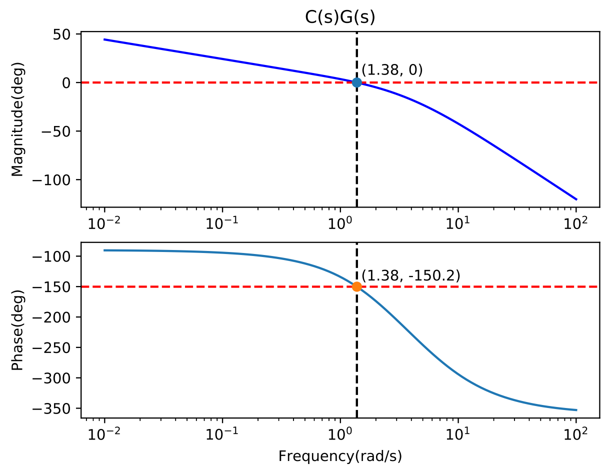

Fig. 2.3

eters to be changed accordingly to get exact results.

3 PID Controller

3.1 Introduction